Morphometry of Two Species of the Squid Family Ommastrephidae

BY

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(3 Text figures; 2 Tables)

INTRODUCTION

It is common practice in cephalopod taxonomy to record certain morphological measurements from specimens. Each measurement is usually divided by the dorsal mantle length to give a ratio, sometimes referred to as an index. In recent years, due to the greater frequency of oceanic cruises and improved sampling techniques, enough specimens of some oceanic species have been collected to examine the variability of these measurements and ratios for a large range of sizes.

It has been shown that these ratios can change as the mantle length increases (Haefner, 1964; Spencer, 1969). Two interpretations of this type of analysis have been made. Haefner (1964) suggests that his data provide "useful information for specific identification and classification of most size groups of both *Loligo pealei* and *Lolliguncula brevis*" while Spencer (1969) concludes that the differences in relative growth patterns and gross morphology (of the fins) are indicative of the degree to which the fins are responsible for maintenance of vertical position and locomotion at slow speeds in the two species he examined.

When morphometric data for two other species of oegopsid squid were analyzed in the same manner as those previously mentioned, the weaknesses of that type of analysis were apparent. This paper presents an alternative method of analysis of three selected characters of *Symplectoteuthis oualaniensis* (Lesson, 1830) and *S. luminosa* Sasaki, 1915. The character measurements are used to calculate "best" fit curves which are fit to the values. The biological meaning of the curves is discussed with respect to isometric and allometric types of growth. These growth patterns are shown to be occasionally indistinct.

METHODS

Data were obtained for 439 specimens of *Symplectoteuthis oualaniensis* and 82 specimens of *S. luminosa*. All specimens of the former species have the dorsal light organ described in Clarke (1963). Measurements were recorded to the nearest 0.5mm with an average error of 0.5mm. The specimens used in this study were collected on various cruises in the Pacific and Indian Oceans by the Scripps Institution of Oceanography. The morphological characters examined in this paper are: dorsal mantle length (ML), mantle width (MW), fin length (FL) and fin width (FW). A description of these measurements is found in Haefner (1964). In my study MW was always measured at the mantle opening. Of the eight characters presented in Spencer (1969), these showed the largest changes with respect to mantle length.

The data were examined in several ways. For purposes of comparison the method of Haefner (1964) and Spencer (1969) was used. This process converts the data to ratios which are averaged within 10mm ML intervals. In addition, the range and 95% confidence limits on the mean were calculated within each interval. This was done to reflect the number per interval and their variability. When this was done it became apparent that a better type of analysis must be found if any conclusions were to be drawn from the data.

After consulting Marr (1955) on the use of ratios as opposed to measurements, it was decided that the original variates would be more useful. The MW, FL and FW measurements were plotted against ML for both species. For the remainder of the paper these three combinations will be referred to as pairs. Linear and quadratic regression equations were calculated for each pair. The measurements were then transformed to logarithms and both types of regression were used again. For each pair of each species there were four equations as possible fits to the data. For reasons which will be discussed later the linear equations were chosen as the "best" curves and were fit to the data.

RESULTS

The method used by HAEFNER (1964) and SPENCER (1969) has two serious faults. It makes no allowance for having different numbers of individuals in each interval and it does not reflect the variability of ratio values within each interval. These weaknesses can be corrected as mentioned above. When this was done with my data it was clear that any interval with 2 or 3 individuals had very wide confidence limits associated with it as seen in Figure 1. Curve fitting for these graphs seemed inappropriate.

The original variates proved easier to work with. In all pairs, each of the four possible regression equations accounted for a statistically highly significant ($p < .005$) amount of the variability in the measurements. Most of the equations which accounted for the greatest percentage of the total variability involved logarithmic transformations of the data, but they were not much better fits than the linear ones as seen in Table 1.

DISCUSSION

One would expect inherent variability in the data due to differences at three levels: the species, the population and the individual levels. Due to the difficulty in obtaining large single population samples or maintaining live individuals over long periods of time, nothing was done about this nonmeasurement error. The graphs in Figure 1 show that the ratios tend to change most rapidly in juveniles, but are not constant in adults. The taxonomist should be cautioned in using ratios as diagnostic tools since they can be size dependent. The graphs strongly suggest that a reversal in the direction of change of a character ratio in larger individuals such as observed in the FW/ML ratio of *Gonatopsis borealis* by SPENCER (1969) is not a real phenomenon. It is probably an error due to a combination of the inherent variability previously mentioned and the small numbers of larger individuals examined. A very good discussion of the advantages of using measurements over ratios is given in MARR (1955) and examples of the use of ratios in the literature are discussed. The maximum amount of information is present in measurements. Conversion to ratios and subsequent averaging over intervals not only obscures the variability, but produces curves that appear difficult to fit.

Table 1

Percentage of the total variability removed by each type of regression equation (SS(regression)/SS(total) ×100)

Symplectoteuthis oualaniensis	MW on ML	FL on ML	FW on ML
Type I (linear)	95.5	98.1	95.2
Type II (exponential)	96.0	98.4	96.1
Type III (quadratic)	95.5	98.2	95.6
Type IV (log quadratic)	96.5	98.6	96.7

Symplectoteuthis luminosa	MW on ML	FL on ML	FW on ML
Type I (linear)	96.1	99.4	98.4
Type II (exponential)	97.3	99.3	98.6
Type III (quadratic)	96.7	99.4	98.5
Type IV (log quadratic)	97.9	99.3	98.6

Although equations of type IV (see Table 1) generally accounted for the greatest amount of variability, they were not much of an improvement on type I which are plotted in Figure 2. The fact that there was little distinction between linear and exponential types of equations was most surprising at first. The contrast between linear (isometric) and exponential (allometric) growth in fish was examined and found to be as poor. The curve fitting analysis of this paper was used to calculate "best" fit equations for some measurements of striped marlin given in MORROW (1952). MORROW had concluded that sword length and body depth grew isometrically while the dorsal fluke of the caudal fin showed negative allometry. The analysis showed that sword length, body depth and the dorsal fluke of the caudal fin plotted against standard length were all equally well fitted by either linear or exponential equations. Linear equations removed an average of 44.9% of the total variability while exponential ones averaged 44.7%. In this example, then, the two types of growth

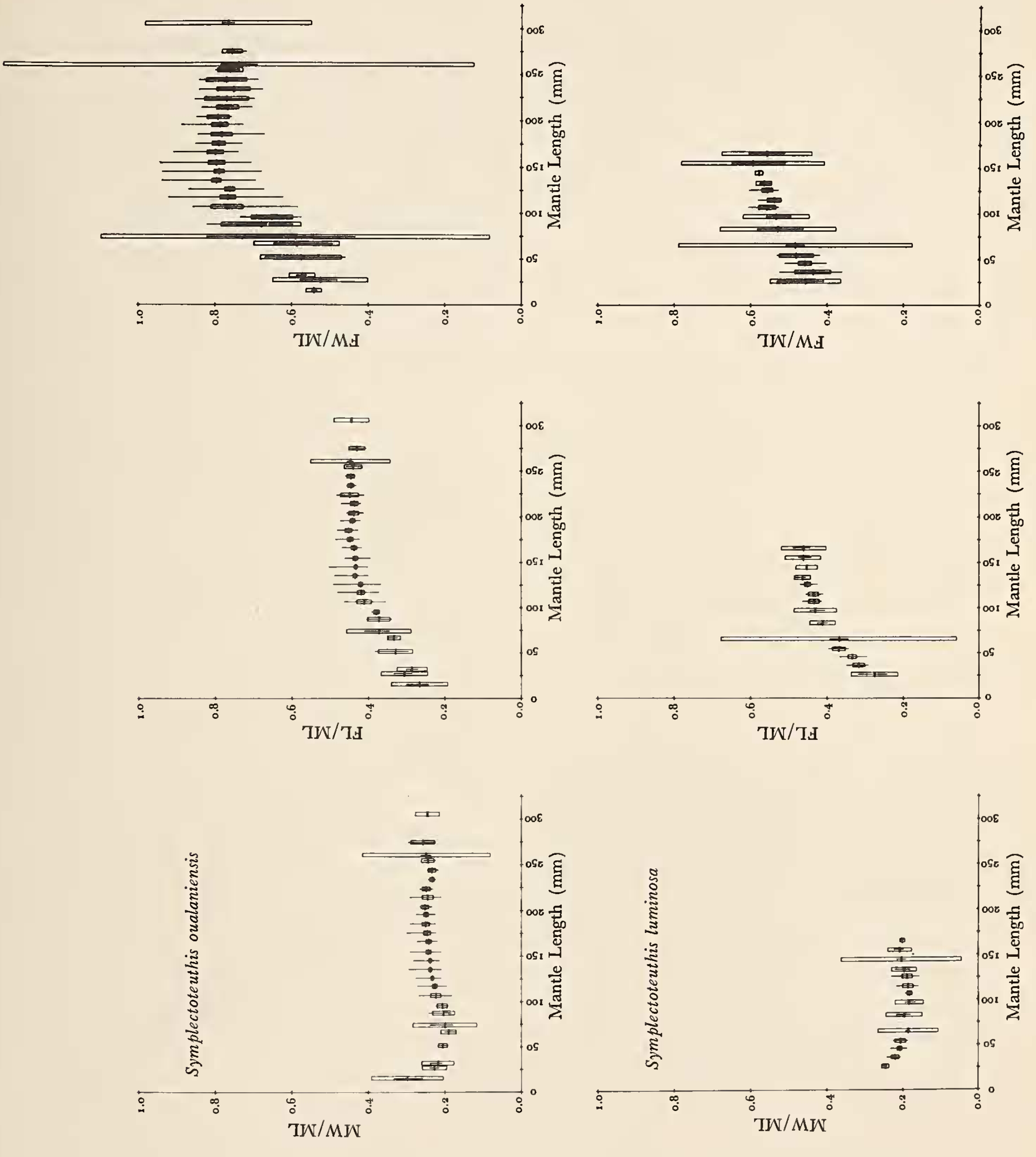

Figure 1

Interval means, ranges and associated 95% confidence limits on the means. The means are represented by the crosses in the centers of the rectangles. The vertical lines inside the rectangles represent the range of values. The height of the rectangles represents the 95% confidence limits on the means (their width has no meaning).

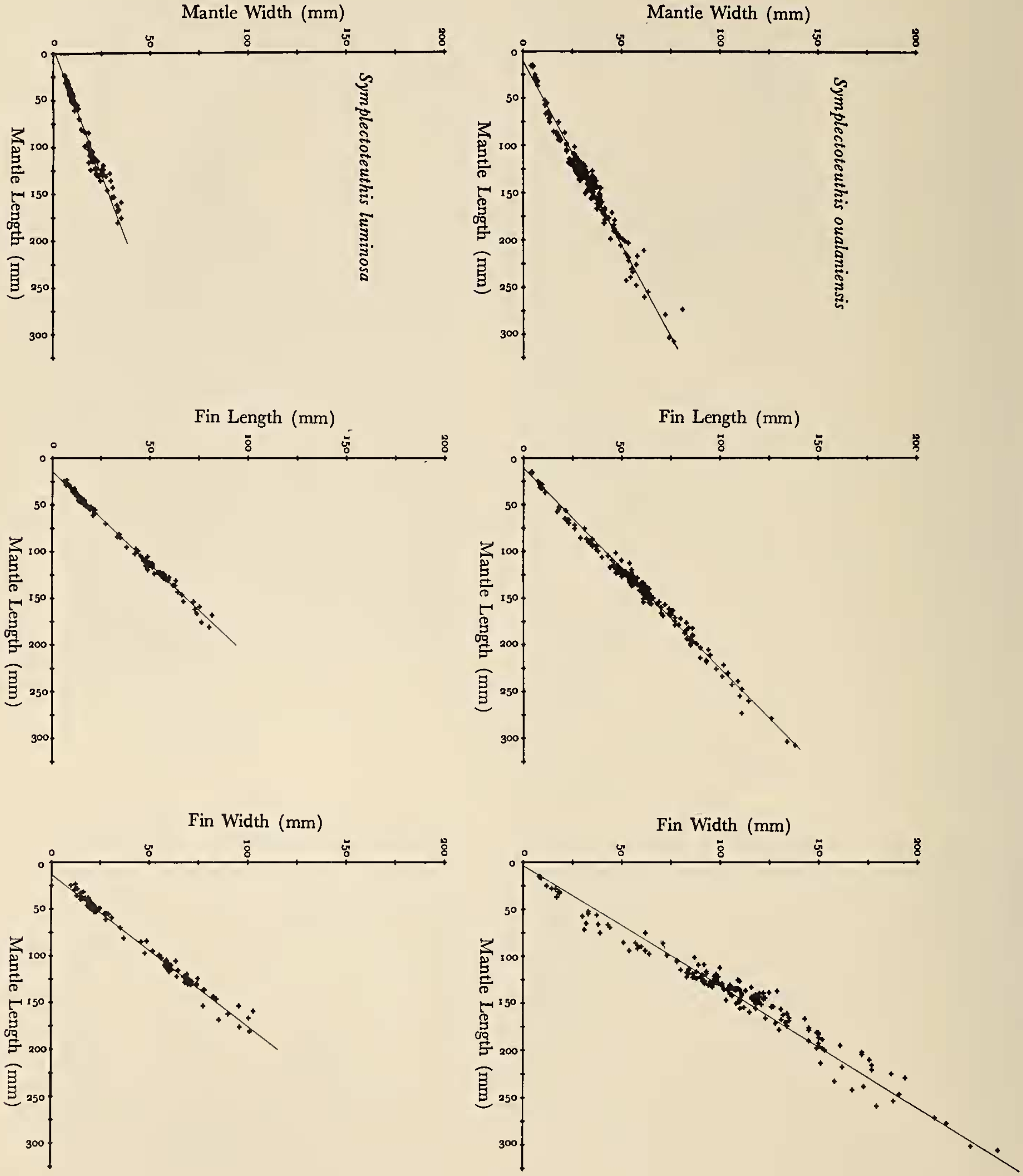

Figure 2

The original variates and their calculated linear equations.

were statistically indistinguishable. A similar situation was found when measurement data of yellowfin tuna (Schaefer, 1948) were analyzed in the same manner. Schaefer stated that head length grows linearly with respect to total length. The curve fitting analysis showed that the exponential equations give as good a fit as the linear ones (99.2% of the total variability v. 99.3% respectively).

A similar analysis applied to two other species in the family Ommastrephidae, *Dosidicus gigas* (d'Orbigny, 1835) (218 specimens) and *Ommastrephes bartramii* (Lesueur, 1821) (96 specimens) with fin shapes very similar to *Symplectoteuthis oualaniensis,* agree in the overall trends shown in this paper. In some cases an exponential equation fit "best" while in other cases the linear ones fit "best" (see Table 2). The general trends of the two species presented in Figure 2 agree. Their fin shapes (Figure 3) are very similar to those examined by Spencer (1969). The differences he observed and attributed to different fin shapes must be peculiar to the two species he examined, not the fin shapes.

Table 2

Percentage of the total variability removed by each type of regression equation (SS(regression)/SS(total) ×100)

Dosidicus gigas	MW on ML	FL on ML	FW on ML
Type I (linear)	97.1	99.1	98.0
Type II (exponential)	98.1	97.2	99.0
Type III (quadratic)	97.3	99.1	99.2
Type IV (log quadratic)	98.7	99.4	99.0

Ommastrephes bartramii	MW on ML	FL on ML	FW on ML
Type I (linear)	94.4	97.7	95.8
Type II (exponential)	94.4	97.7	96.2
Type III (quadratic)	94.4	98.1	96.3
Type IV (log quadratic)	94.4	97.9	96.7

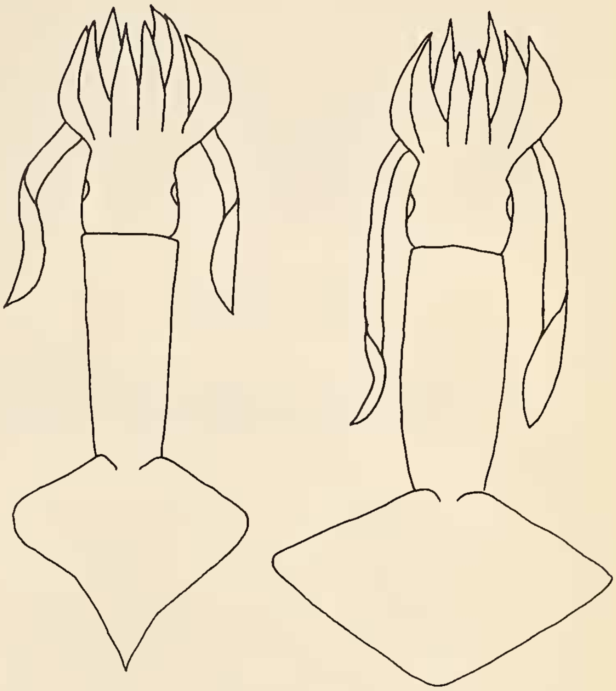

Figure 3

External morphology of *Symplectoteuthis oualaniensis* (right) (170mm ML) and *S. luminosa* (left) (160mm ML).

If the calculated curves for any character pair are compared for the two species of *Symplectoteuthis* discussed here, they are sufficiently distinct for taxonomic identification as also found by Haefner (1964) with ratio curves. When the observed points are compared, however, the variability around the calculated curves is more than enough to obscure this distinction and make the identification impossible by means of MW and FL. Using FW and ML, the distinction is satisfactory beyond 100mm ML while below this it would be questionable. If the reader desires a quantitative separation, the use of discriminant functions is suggested (Fisher, 1958), however there are usually qualitative characters which permit a faster specific separation than the type of data presented in this paper.

ACKNOWLEDGMENTS

The author wishes to thank the numerous persons involved in the collection of the specimens used in this study: staff, students and ship personnel. Helpful criticism of the manuscript was given by Drs. J. A. Mc Gowan, T. Okutani and E. W. Fager to whom I am indebted. The work was supported by the Marine Life Research Program, the Scripps Institution of Oceanography's part of the California Cooperative Oceanic Fisheries Investigations, which are sponsored by the Marine Research Committee of the State of California and by the National Science Foundation Grant GB 12413.

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